

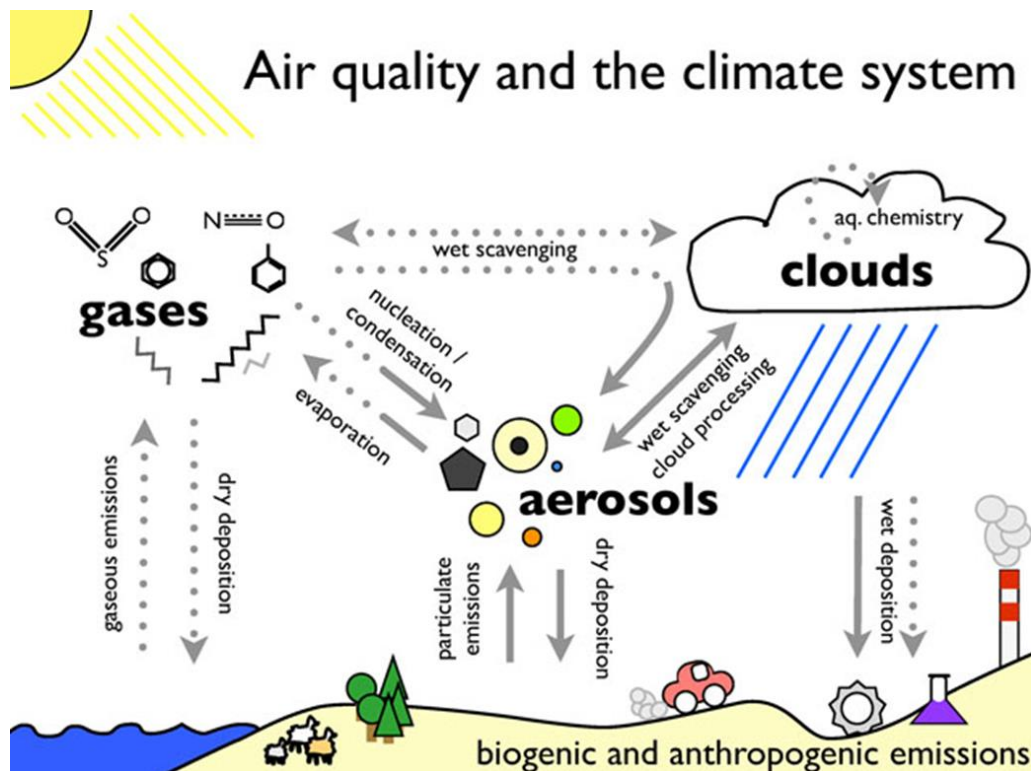
Willkommen  
Welcome  
Bienvenue



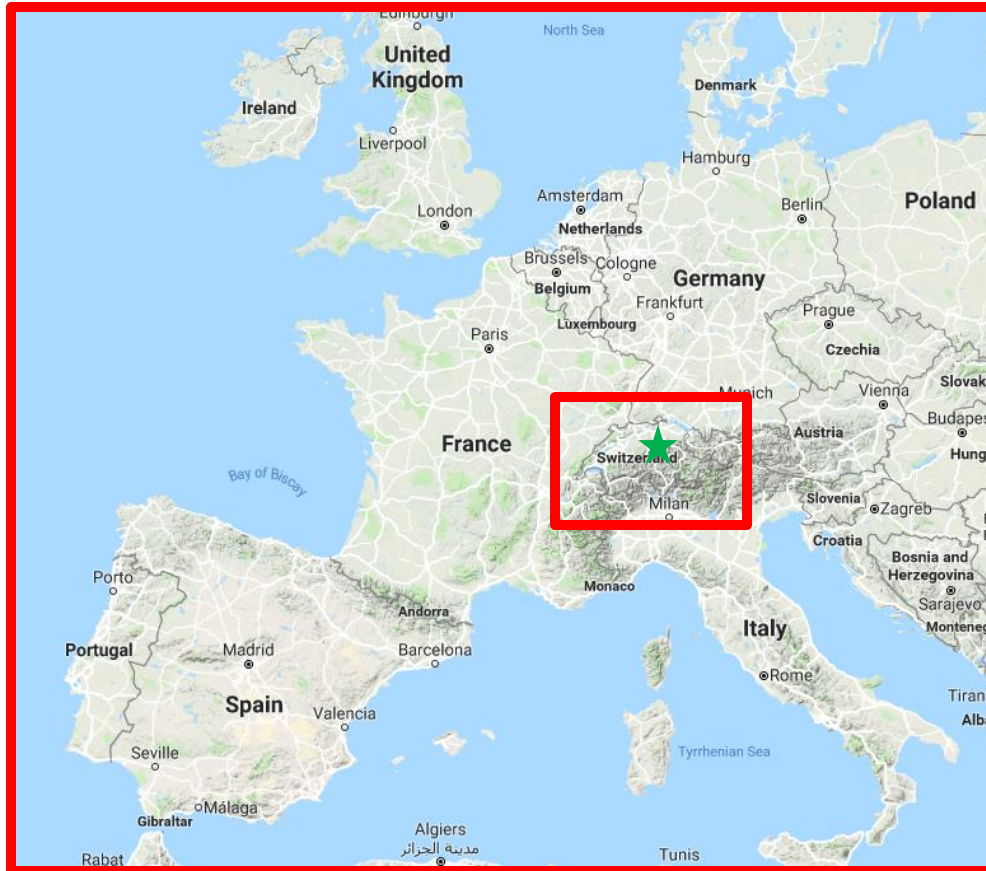
# An evaluation of high-resolution nested European and Swiss COSMO-ART chemistry transport simulations

Qing Mu

# COSMO-ART model system



# Project overview: multi-scale air quality modeling



(picture from Google Map)

## Multi-scale modelling system

Regional-scale atmospheric chemistry transport model **COSMO-ART**

- ✓ Detailed physical/chemical schemes
- ✓ High resolution
  - EU domain 14x14 km
  - Switzerland domain 2x2 km

~~X Street level~~

Urban-scale Eulerian model **GRAMM/GRAL**

- ✓ Complex topography & building configurations
- ✓ Very high resolution 10 m

~~X Background~~

background

# COSMO-ART model setup

## Model input

### IC/BC

Meteorol. IC/BC  
domain 1: ECMWF  
domain 2: domain 1

Chemical IC/BC  
domain 1: MOZART  
domain 2: domain 1

### Anthr. emissions

TNO/MACC  
outside Switzerland

MeteoTest  
Switzerland

### Obs. nudging

Meteorology  
MeteoSwiss

## COSMO-ART model

### Meteorology

COSMO

### Online emission

Biogenic VOCs  
(Guenther et al. 2012)

### Gas phase chemistry

RADMK  
chemistry scheme

PAPA  
online photolysis rate

### Aerosols

MADesoot  
6 mode, soot aging

SIA  
ISORROPIA II

SOA  
VBS

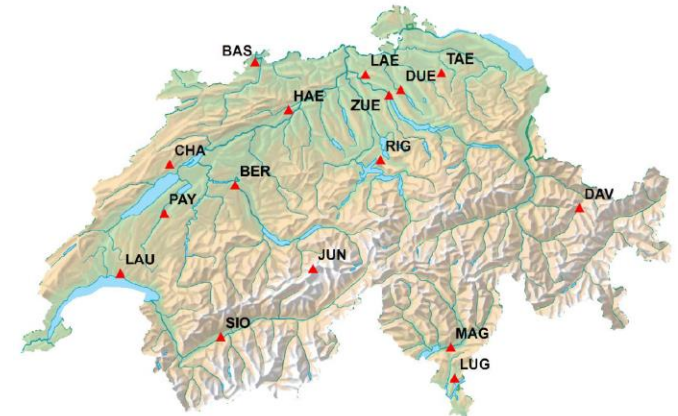
## ■ Observation data

- NABEL stations (N=15): Meteorology, gases, aerosols
- Kanton stations (N=174): O<sub>3</sub>, NO<sub>2</sub>, NO, PM<sub>10</sub>

## ■ Simulation period

- 27.06.2015-18.07.2015 (a high O<sub>3</sub> event)

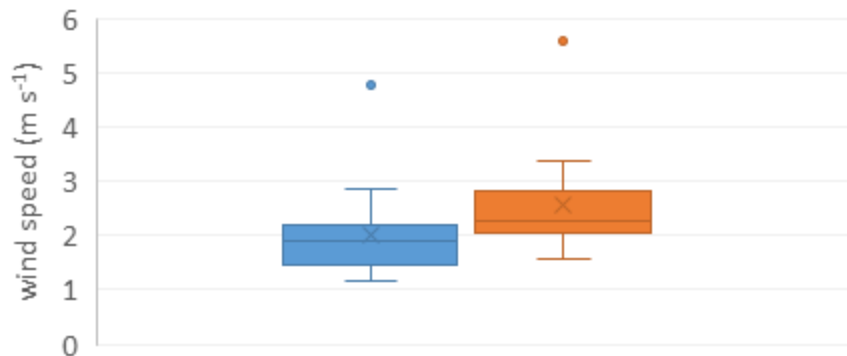
Map of NABEL stations



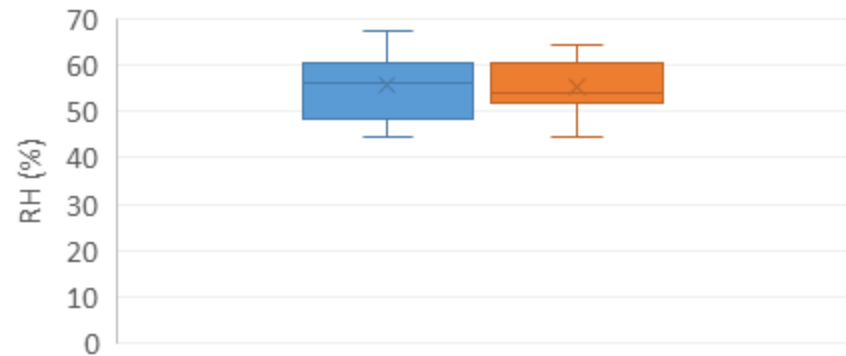
# Evaluation of meteorology

■ Obs ■ Mod

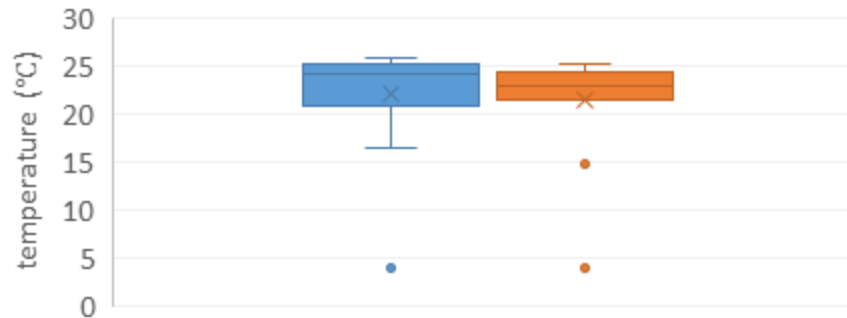
Wind Speed (N=15)



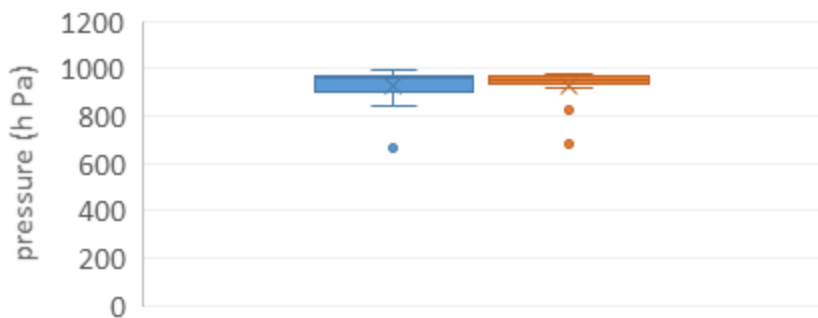
Relative Humidity (N=15)



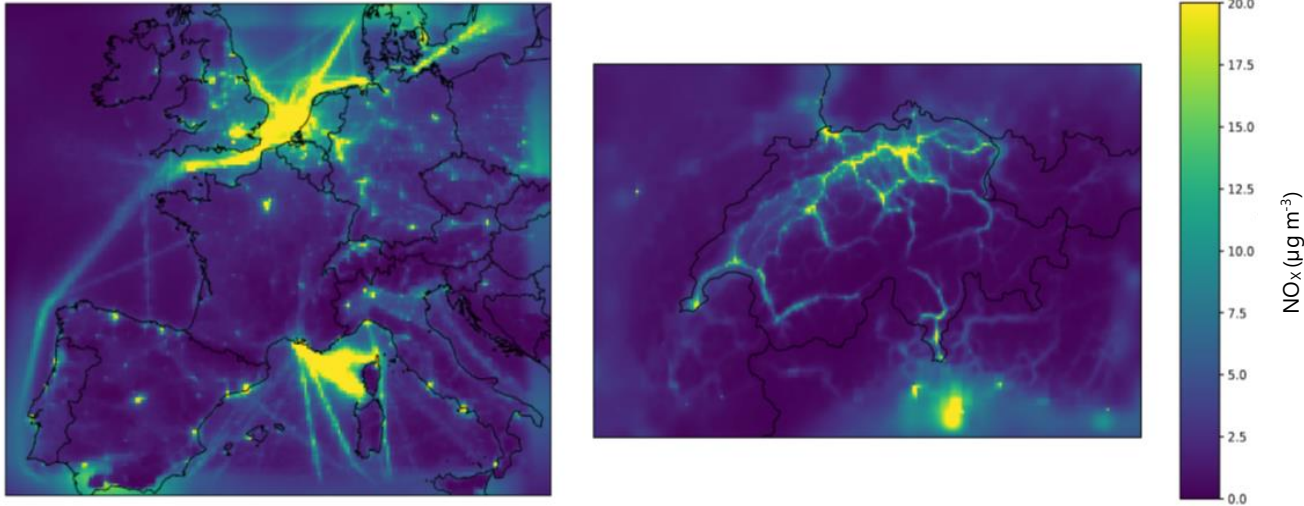
Temperature (N=15)



Pressure (N=15)



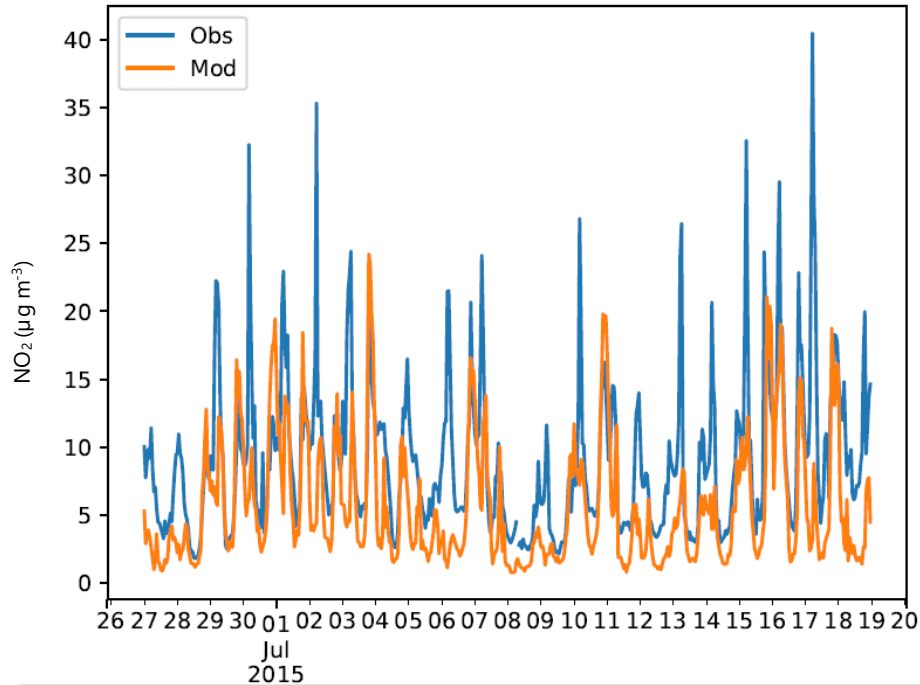
# Evaluation of NO<sub>x</sub> (1)



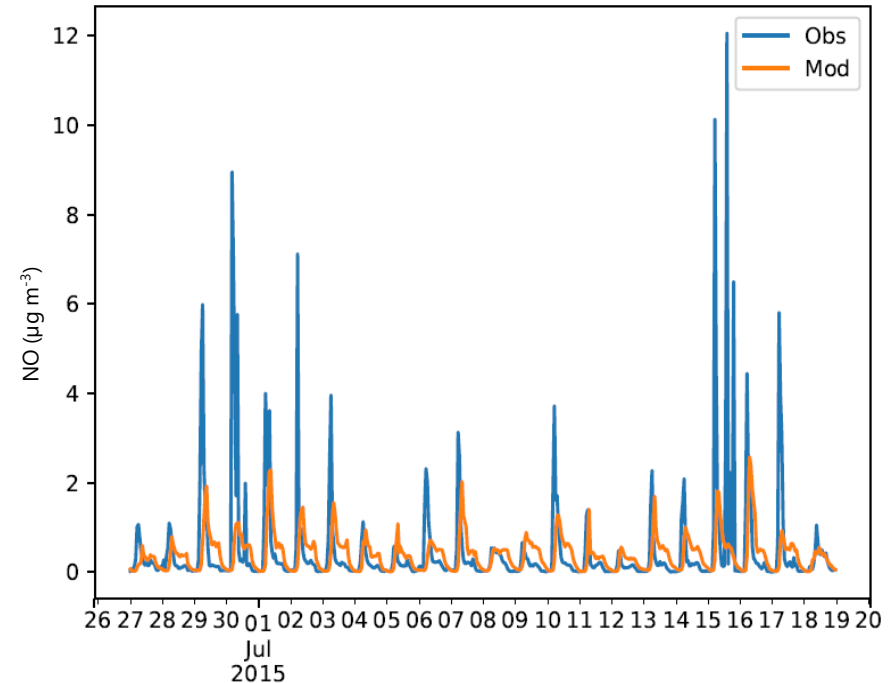
NO<sub>x</sub> distribution in the EU domain (left) and Switzerland domain (right)

# Evaluation of NO<sub>x</sub> (2)

## NO<sub>2</sub> @Payerne

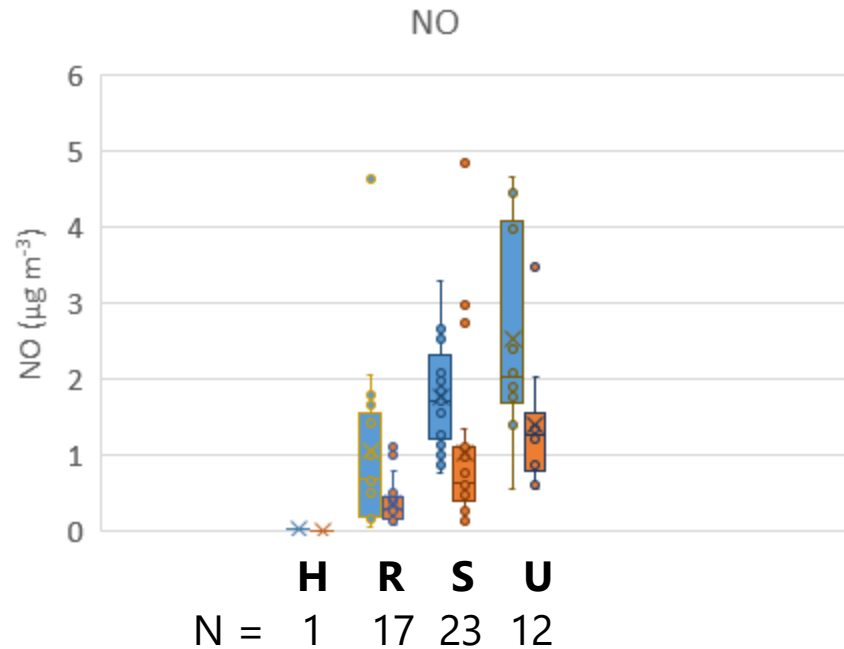
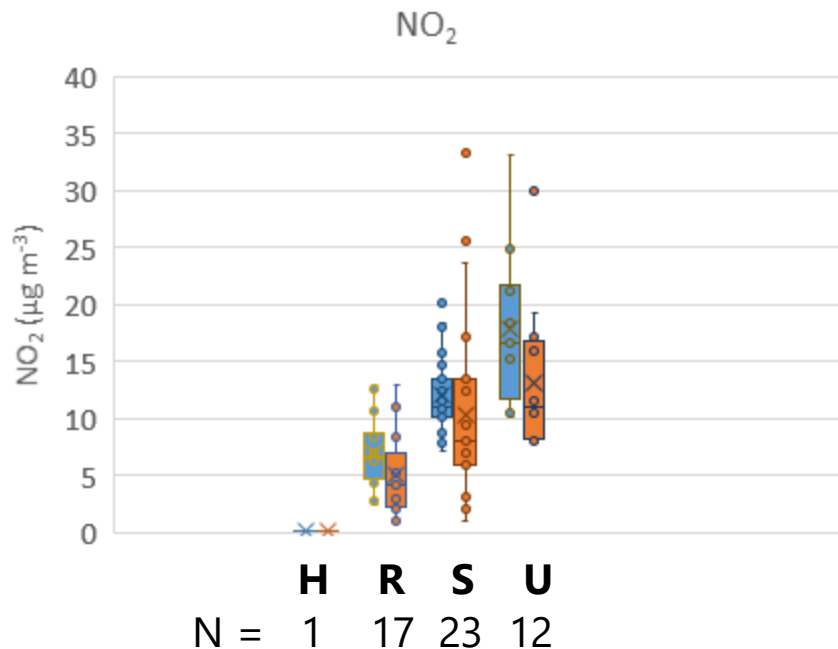


## NO @Payerne





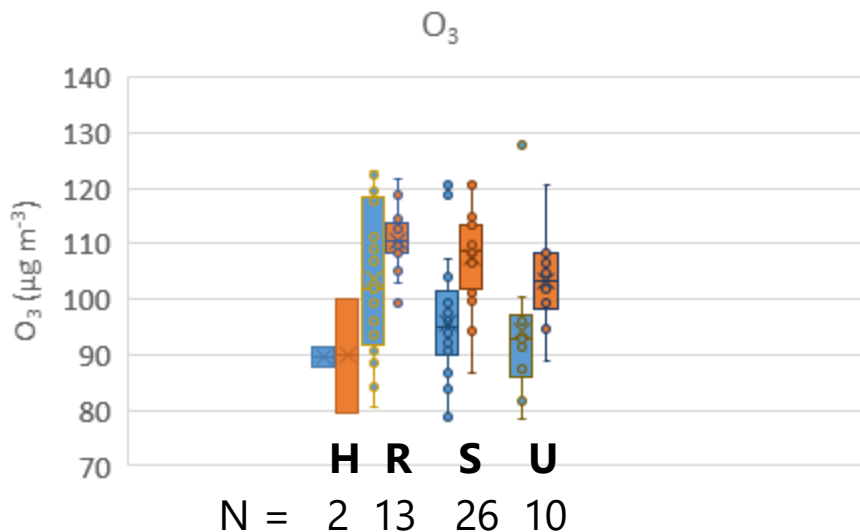
# Evaluation of NO<sub>x</sub> (3)



(All background sites. **H**: high mountain **R**: rural **S**: suburban **U**: urban)

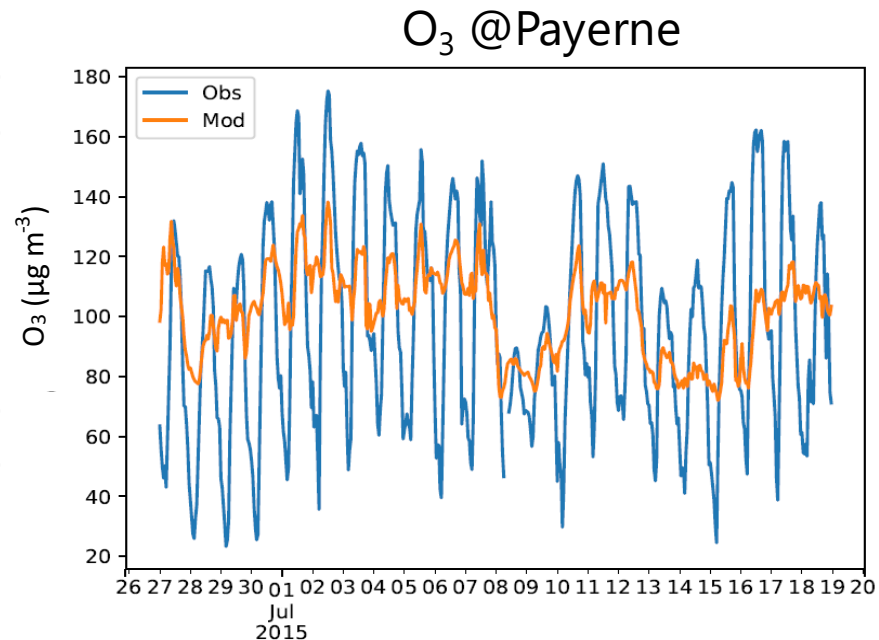
The relative level of background concentrations (HB, RB, SB, UB) are well captured

# Evaluation of O<sub>3</sub>



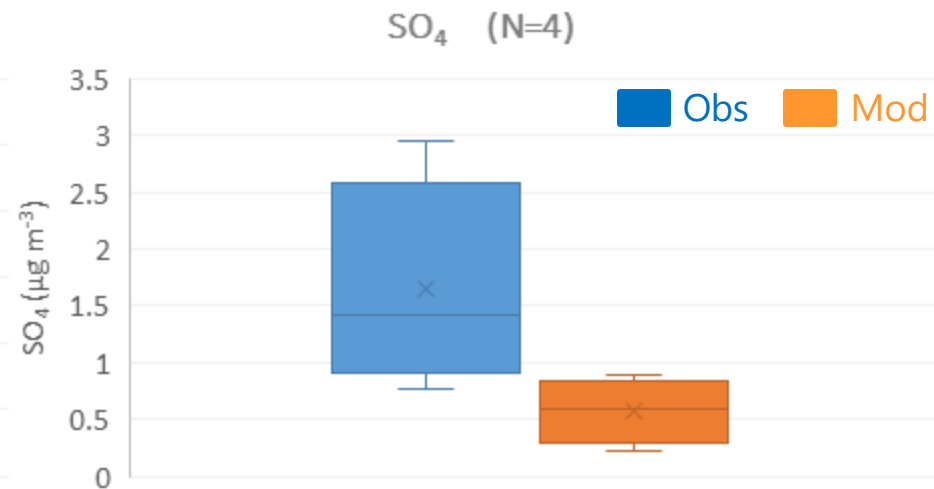
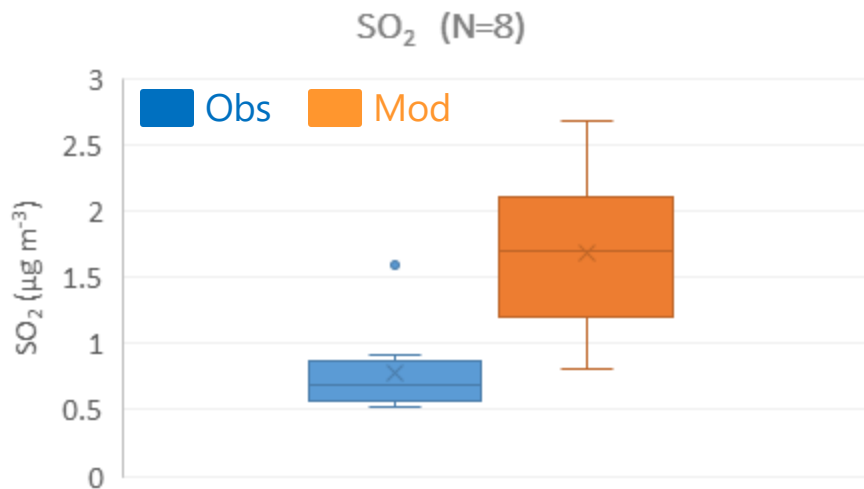
(All background sites.

**H**: high mountain **R**: rural **S**: suburban **U**: urban)



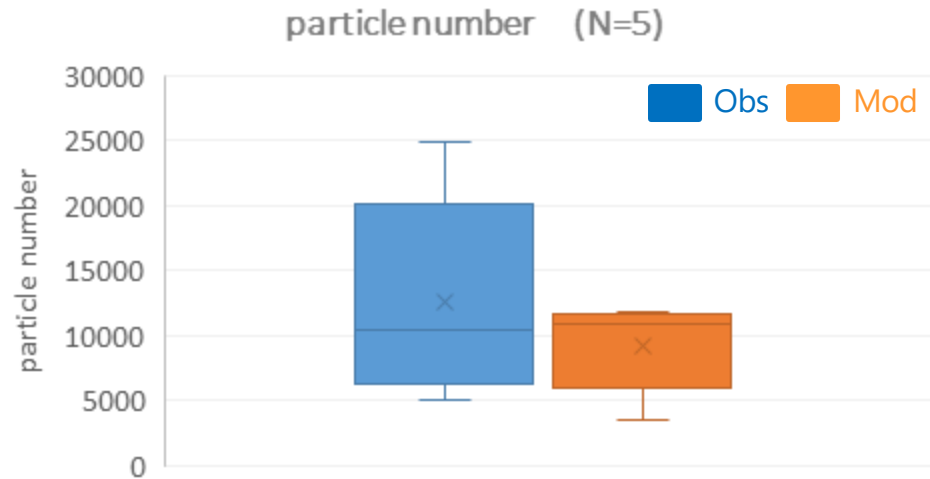
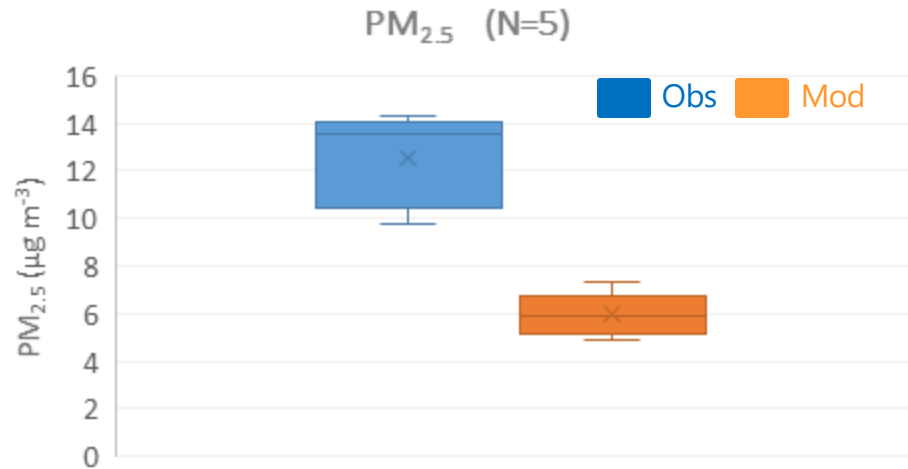
- Too much mixing in nighttime; chemistry problem in daytime
- Background O<sub>3</sub> concentration 118 µg m<sup>-3</sup> is too high compared with observation 100 µg m<sup>-3</sup>

# Evaluation of SO<sub>2</sub> / SO<sub>4</sub>



- Missing aqueous-phase chemistry of SO<sub>2</sub> in the standard model version
- Implemented reactions:  
 $\text{SO}_2 (\text{aq}) + \text{H}_2\text{O}_2 (\text{aq}) \rightarrow \text{SO}_4 (\text{aq})$        $\text{SO}_2 (\text{aq}) + \text{O}_3 (\text{aq}) \rightarrow \text{SO}_4 (\text{aq})$

# Evaluation of PM<sub>2.5</sub>



- The old Swiss emission inventory could be too low (TNO / CH = 1.56)
- Updated inventory needs to be tested

# Evaluation of volatile organic compound (VOC)

- VOC covers a lot of compounds, aggregating into groups
- Challenge for models: link model output groups with measurement.

## COSMOART

ETH (ethane)

OL2 (ethene)

HC3 (alkanes low OH rate constants) + HC5  
(alkanes mean OH rate constants) + HC8  
(alkanes high OH rate constants)

OLT (terminal alkenes) + OLI (internal alkenes)

TOL (toluene and less reactive aromatics)

XYL (xylene and more reactive aromatics)

ALD (acetaldehyde and higher aldehydes)

KET (ketones)

## NABEL

C2 (ethane)

C2en (ethene)

C3 (propane)+C4Iso (isobutane)+C4 (n-butane)+C5Iso  
(isopentane)+C5 (n-pentane)+C6IsoS (sum of isohexanes)+C6  
(n-hexane)+C7IsoS (sum of isoheptanes)

C3en (propene)+C4enS (sum of butenes)+C4en13 (1,3-  
butadiene)+C5enS (sum of pentenes)

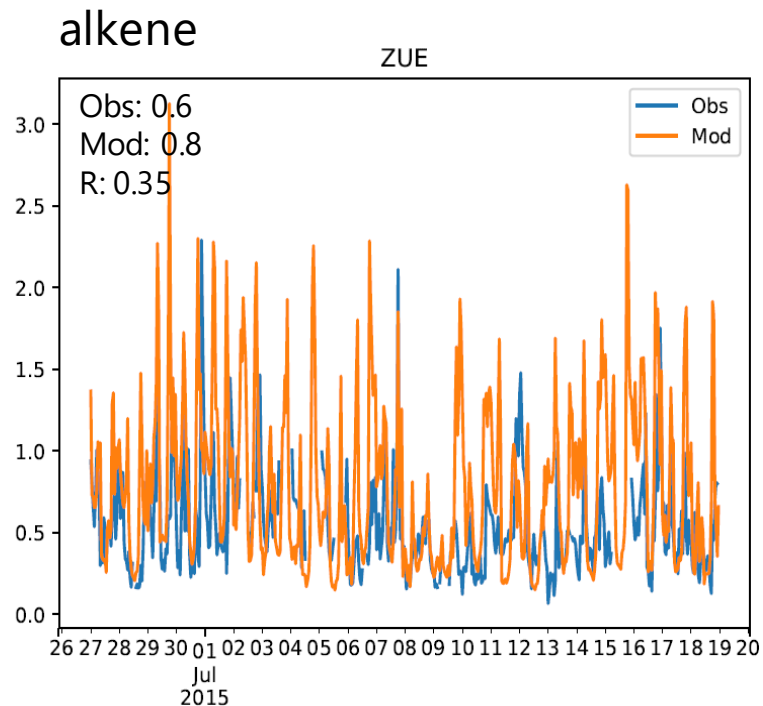
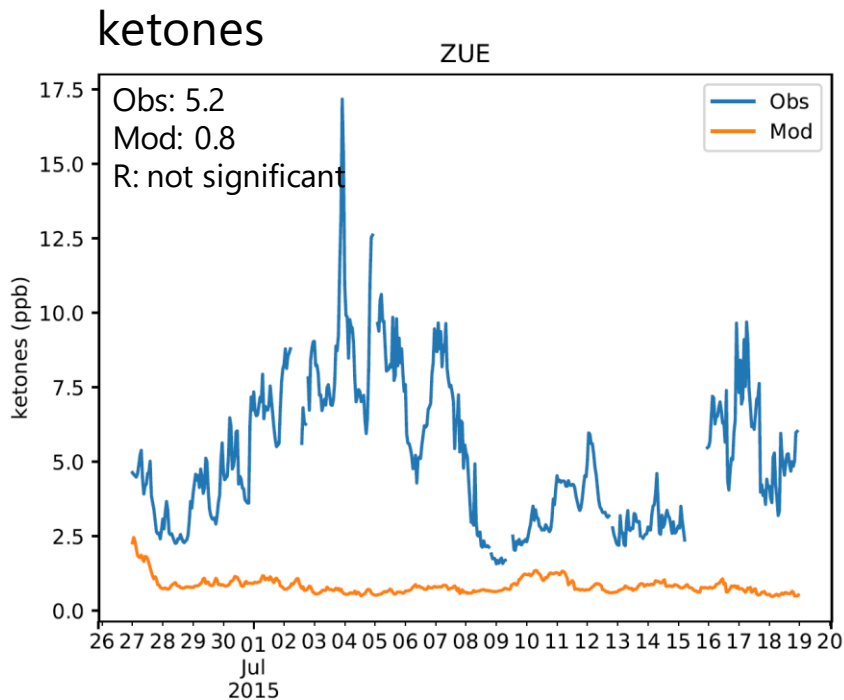
Toluol (toluene)+Benzol (benzene)

mpXylol (sum of m-p-xylene)+oXylol (o-xylene) +C2Benzol  
(ethylbenzene)

Ethanal (acetaldehyde)

MEK (methyl ethyl ketone)+Aceton (acetone)

# Evaluation of volatile organic compound (VOC)



➤ Missing biogenic VOC emissions

## ■ **Summary**

- Problems with total and speciation of Swiss emission inventory.
- Missing aqueous-phase chemistry of  $\text{SO}_2$  leads to overestimate of  $\text{SO}_2$  and underestimate of  $\text{SO}_4$  (implemented).
- Missing biogenic VOC emissions leads to underestimate of VOCs and problems of VOC-related chemistry (corrected).

## ■ **Outlook**

- Re-evaluate model performance with the implemented aqueous-phase chemistry of  $\text{SO}_2$ , corrected biogenic VOC scheme, and the new Swiss emission inventory.